I, Ikuzo Tanaka, declare as follows:

1. I am a citizen of Japan residing at 24-5, Mejirodai 4-chome, Hachioji-shi, Tokyo, Japan.

2. To the best of my ability, I translated relevant portions of:

Japanese Patent Laid-Open No. 61-157655

from Japanese into English and the attached document is a true and accurate abridged English translation thereof.

3. I further declare that all statements made herein are true, and that all statements made on information and belief are believed to be true; and further that willful false statements and the like are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Date: June 24, 2009

Ikuzo Tanaka

Ikuzo Tanaka

ABRIDGED TRANSLATION

Japanese Patent Laid-Open No. 61-157655

Application No. 59-277759

Filing Date: December 28, 1984

International Classification: C22C 37/10

B21B 25/00

Inventors: Yoshitomo Hitachi, and Mitsuhiko So

Applicant: DAIDO STEEL CO., LTD.

Address: 66, Aza-kuridashi, Hoshizaki-cho, Minami-ku, Nagoya-shi

TITLE OF THE INVENTION

CASTING TOOL

Claim 2:

A cast alloy iron tool comprising being made of a material comprising 3.0-7.0% of C, 5.0% or less of Si, 3.0% or less of Mn, 0.5-40.0% of Ni, 0.5-20.0% of Cr, and one or more of 0.5-30.0% of Cu, 0.1-30.0% of Co, 0.1-10.0% of Mo, 0.1-10.0% of W, 0.05-5.0% of V, 0.01-3.0% of Nb, 0.01-3.0% of Zr and 0.01-3.0% of Ti, the balance being substantially Fe, having a graphite area ratio of 5.0% or more, and a precipitated carbide or carbonitride area ratio of 1.0% or more.

Page 2, right upper-side column, line 9 to left lower-side column, line 18:

[Problems to be solved by the Invention]

The object of the present invention is to provide a cast alloy iron tool excellent in seizure resistance and wear resistance in tools such as guide shoe, plug, etc. used for manufacture of seamless steel pipe.

Structures of the present invention

[Means for Solving the Problems]

The cast alloy iron tool comprises being made of a material comprising 3.0-7.0% of C, 5.0% or less of Si, 3.0% or less of Mn, 0.5-40.0% of Ni, 0.5-20.0% of Cr, the balance being substantially Fe, wherein a graphite area ratio of 5.0% or more, and a precipitated carbide or carbonitride area ratio of 1.0% or more.

As the composition of the cast alloy iron, it is preferable to use a cast alloy having a composition comprising, in addition to the above, one or more of 0.5-30.0% of Cu, 0.1-30.0% of Co, 0.1-10.0% of Mo, 0.1-10.0% of W, 0.05-5.0% of V, 0.01-3.0% of Nb, 0.01-3.0% of Zr and 0.01-3.0% of Ti, thereby making it possible to improve the properties of the cast alloy iron tool.

In any compositions mentioned above, the structure of the cast alloy iron is converted to a martensite phase system, an austenite phase system or a two-phases structure comprising an admixture thereof by alloy elements of Ni, C, Mn, Cr, Mo, Si, etc., which are solidly dissolved in the matrix, and the use of the cast alloy iron should be appropriately distinguished in accordance with the properties required for the tool. In outline, in the case of 5% or less of Ni, there is obtained a martensite phase system, while in the case of 8% or more, there is obtained an austenite phase system, and in the case therebetween, there is obtained an admixed

two-phases system.

Page 2, right lower-side column, lines 12-15:

The wear resistance is achieved by the dispersion of hard particles. The hard particles are mainly crystallized carbides or carbonitrides of Cr, and it can be improved by securing the area ratio of 1.0%.

Page 3, left upper-side column, lines 10-14:

Ni: 0.5-40.4%

Not only promoting the graphitization but also increasing toughness. Although this effect is recognized in an amount of 0.5% or more, and is further obtained in a wide range, when the Ni content exceeds 40%, there is found a tendency to disturb the graphitization.

Page 3, left upper-side column, lines 15-18:

Cr: 0.5-20.0%

As mentioned above, by forming carbides thereof, the wear resistance, particularly, wear resistance at a high temperature is improved. However, since it disturbs the graphitization, its range should be limited within the above.

Page 3, left lower-side column, lines 4-14:

[Example]

Using a high-frequency induction furnace, alloy irons shown in a table (at page 4) were solved to cast by a treatment for subjecting graphites to spheroidizing by inoculating Ni-Mg. Test materials can be classified as follows.

(Present Invention)	Nos. 1-5: Martensite phase system, and
	Nos. 6-9: Austenite phase system;
(Comparative Examples)	No. 10: 1.5C-24Cr-4Ni system,
	No. 11: 1.3C-35Ni-35Cr system,
	No. 12: Ductile cast iron, and
	No. 13: "Ni-Resist" (a wear-resistant alloy).

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 61-157655
(43)Date of publication of application : 17.07.1986

(51)Int.Cl. C22C 37/10
B21B 25/00

(21)Application number : 59-277759
(22)Date of filing : 28.12.1984

(71)Applicant : DAIDO STEEL CO LTD
(72)Inventor : HITACHI YOSHITOMO
SO MITSUHIKO

(54) CASTING TOOL

(57)Abstract:
PURPOSE: To manufacture casting tool superior in resistance for burning and wear, by spheroidizing graphites in cast iron having a specified compsn. contg. Ni, Cr, etc., dispersing them, and using alloy cast iron in which hard metal carbides and carbonitrides are pptd.
CONSTITUTION: Material such as guide shoe of drawing machine used for manufacture of seamless steel pipe, plug used for punch rolling or drawing rolling, is made of alloy cast iron contg. by weight, 3W7% C, <5% Si, <3% Mn, 0.5W40.0% Ni, 0.5W20.0% Cr, or further one or ≥2 kinds among 0.5W30% Cu, 0.1W30% Co, 0.1W10% Mo, 0.1W10% W, 0.05W5% V, 0.01W3% Nb, 0.01W3% Zr, 0.01W3% Ti. Graphites in the cast iron are spheroidized by Mg system inoculation agent and dispersed in ≥5% sectional area thereof, and hard carbides, carbonitrides of various metals are pptd. in ≥1% area ratio during solidification.

⑲日本国特許庁（JP）　⑪特許出願公開

⑫公開特許公報（A）　昭61－157655

⑤Int.Cl.⁴　識別記号　庁内整理番号　㊸公開　昭和61年(1986)7月17日

C 22 C 37/10　7518－4K
B 21 B 25/00　7819－4E

審査請求　未請求　発明の数 1　（全5頁）

㊿発明の名称　鋳造工具

㉑特　願　昭59－277759

㉒出　願　昭59(1984)12月28日

⑫発明者　常陸　美朝　名古屋市緑区桶山1丁目28番地
⑫発明者　宗　光彦　江南市大字木賀695－3番地
⑪出願人　大同特殊鋼株式会社　名古屋市南区星崎町字繰出66番地
⑭代理人　弁理士　須賀　総夫

明細書

1．発明の名称

鋳造工具

2．特許請求の範囲

（1）　C：3．0～7．0％、Si：5．0％以下、Mn：3．0％以下、Ni：0．5～40．0％およびCr：0．5～20．0％を含有し、残部が実質的にFeからなる合金鋳鉄であって、黒鉛の面積率が5．0％以上、晶出した炭化物または炭窒化物の面積率が1．0％以上である材料で製造した鋳造工具。

（2）　C：3．0～7．0％、Si：5．0％以下、Mn：3．0％以下、Ni：0．5～40．0％およびCr：0．5～20．0％に加えて、Cu：0．5～30．0％、Co：0．1～30．0％、Mo：0．1～10．0％、W：0．1～10．0％、V：0．05～5．0％、Nb：0．01～3．0％、Zr：0．01～3．0％およびTi：0．01～3．0％の1種または2種以上を含有し、残部が実質的にFeからなる合金鋳鉄であって、黒鉛の面積率が5．0％以上、晶出した炭化物または炭窒化物の面積率が1．0％以上である材料で製造した鋳造工具。

（3）　継目無鋼管の製造に用いる延伸機のガイドシューまたはプラグである特許請求の範囲第1項または第2項の鋳造工具。

3．発明の詳細な説明

発明の目的

［産業上の利用分野］

本発明は、耐焼付性と耐摩耗性にすぐれた鋳造工具に関する。

［従来の技術］

主として継目無鋼管の製造に用いる延伸機のガイドシュー、穿孔圧延または延伸圧延に用いるプラグは、熱的にも機械的にも苛酷な条件下に使用され、管材への焼付きおよび管材との摺動による摩耗が起りやすいので、これがなるべく少い工具が要求されている。

従来、この用途には、高炭素高クロム（たとえば1．5C－24Cr－4Ni）のマルテンサイト系鋳造工具や、高炭素高クロム高ニッケル（たとえば1．3C－35Cr－35Ni）のオーステナト系鋳造工具が多く使われていた。 これらにの鋳造工具は，主として凝固時に晶出した一次炭化物によって、必要な耐摩耗性と耐焼付き性とを発揮するようにしたものである。

管材として普通鋼を対象としていた間は、上記のような工具で足りたが、近年はステンレス鋼や高Si鋼などの、焼付きが起りやすいものが対象とされるようになってきた。 普通鋼でも、要求される品質の基準が高くなっているので、管製造時に生じる小さなキズや軽度の焼付きも避けたい。

従来の鋳造工具は、こうした要求に十分こたえられるものではない。

［発明が解決しようとする問題点］

本発明の目的は、主として継目無鋼管の製造において使用するガイドシュー、プラグなどの工具において、耐焼付き性および耐摩耗性を改善した鋳造工具を提供することにある。

発明の構成

［問題点を解決するための手段］

本発明の鋳造工具は、C：3．0～7．0％、Si：5．0％以下、Mn：3．0％以下、Ni：0．5～40．0％およびCr：0．5～20．0％を含有し、残部が実質的にFeからなる合金鋳鉄であって、黒鉛の面積率が5．0％以上、晶出した炭化物または炭窒化物の面積率が1．0％以上である材料で製造したことを特徴とする。

合金鋳鉄の組成としては、上記に加えて、Cu：0．5～30．0％、Co：0．1～30．0％、Mo：0．1～10．0％、W：0．1～10．0％、V：0．05～5．0％、Nb：0．01～3．0％、Zr：0．01～3．0％ および Ti：0．01～3．0％の1種または2種以上を含有させたものを使用してもよく、これにより特性のいっそうの向上がはかれる。

上記のいずれの組成であっても、組織は基地に固溶しているNi，C，Mn，Cr，Mo，Siなどの合金元素によって、マルテンサイト系、オーステナイト系、またはそれらが混合した二相系となり、工具に要求される特性によって、それぞれ適宜使い分ける。 概略のところ、Ni：5％以下ではマルテンサイト系、8％以上ではオーステナイト系であり、この間では二相混合系となる。

［作 用］

本発明の鋳造工具となる合金鋳鉄の組成限定理由を記せば、つぎのとおりである。

C：3．0～7．0％、黒鉛の面積率：5．0％以上、晶出した炭化物または窒化物の面積率：1．0％以上

本発明で採用した高C含有量は、主として耐焼付き性を高めることを目的としたものであって、組織中に黒鉛を球状に分散させ、面積率を5％以上にすることによって，目的が達成できる。 Cの下限3．0％はこの効果を得るために必要であり、上限7．0％は靭性の低下を配慮して定めた。

耐摩耗性は、硬質粒子の分散によって得る。硬質粒子は、主として鋳造時に晶出するCrの炭化物または炭窒化物であって、面積率1％を確保することによって改善がはかれる。

前記した任意添加元素をも含有する場合は、Mo，Wなどの炭化物、炭窒化物も耐摩耗性に寄与する。

Si：5．0％以下

Cの黒鉛化を進める上で重要な元素である。

また、基地の強度の向上と鋳造時の湯流れをよくするはたらきがある。多量に存在すると靱性が低下するので、5.0%以下に止める。

Mn:3.0%以下
基地に固溶して強度を高めるはたらきがあるが、黒鉛化にとっては好ましくない存在である。被削性を低下させる元素でもあるので、上記した限度内の添加とする。

Ni:0.5~40.4%
黒鉛化を促進するとともに靱性を高める。この効果は0.5%以上で認められ、広い範囲にわたって得られるが、40%を超えると黒鉛化を妨げる傾向がある。

Cr:0.5~20.0%
上述したように、炭化物を形成して耐摩耗性、とくに高温におけるそれを高る。しかし、黒鉛化を妨げるので、上記の限度内とする。

Cu:0.5~30.0%
それ自体の潤滑効果が、耐摩耗性の向上に寄与する。過大に添加すると材質が脆くなる。

Co:0.1~30.0%
耐熱性を得る上で重要な元素である。また、被加工材との親和力低減による耐摩耗性の向上もはかれる。多量に加えると効果が飽和するし、製品価格を高くするので、上記の限度内で適当な添加量をえらぶべきである。

Mo:0.1~10.0%、W:0.1~10.0%、V:0.05~5.0%
いずれも炭化物を形成し、Cr炭化物による耐摩耗性を助ける。Vは、組織を微細化する効果もある。MoとWとは、上限を超えると耐熱衝撃性が低下し、Vは靱性を低下させる。

Nb:0.01~3.0%、Zr:0.01~3.0%Ti:0.01~3.0%
すべて強力な炭化物形成元素であるから、これらを添加すれば耐摩耗性の向上が顕著である。また、Vとならんで、組織を微細化する効果もある。Tiは、0.3%以下の添加であれば、黒鉛化促進にも役立つ。上限の3.0%を超える添加は、靱性の低下を招くので避けるべきである。

【実施例】
高周波誘導炉を用いて、表に示す組成の合金鉄を溶解し、Ni-Mg接種により黒鉛を球状化させる処理をして鋳造した。供試材は、つぎのように区分される。

(本発明)	No.1~5	マルテンサイト系
	No.6~9	オーステナイト系
(比較例)	No.10	1.5C-24Cr-4Ni系
	No.11	1.3C-35Ni-35Cr系
	No.12	ダクタイル鋳鉄
	No.13	ニレジスト

各供試材の黒鉛および炭化物、炭窒化物の面積率を、画像解析装置によつて測定し算出した。その結果を表に記す。

それとともに、JIS G5101 A号(通称「舟型」)試験片を採取し、下記の熱処理を施してから、耐焼付性および耐摩耗性を試験した。

No.1~5、No.12
焼なまし…900℃×3時間加熱後、
10℃/時の速度で冷却して
600℃に至り、以後空冷。

No.6,No.13 鋳込みのまま。

焼付試験および摩耗試験は、いずれも大越式迅速摩耗試験機を改良した熱間(通電による加熱を利用したもの)摩耗試験機によって実施した。すなわち、回転体として径30mm×厚さ5mmの円板、固定体として厚さ5mmの平板を用い、後者に通電して900℃に加熱しながら、

荷重 3kgf
相当材 SUS304
辷り速度 2.5m/sec
辷り距離 500m

の条件で摩擦させた。試験体と評価法はつぎのとおりであって、

PATENT SPECIFICATION

(11) 1 482 724

1 482 724

(21) Application No. 24367/75 (22) Filed 6 June 1975

(31) Convention Application No. 2428821

(32) Filed 14 June 1974 in

(33) Federal Republic of Germany (DT)

(44) Complete Specification published 10 Aug. 1977

(51) INT CL[2] C22C 37/10

(52) Index at acceptance

C7A 743 748 77X 781 78Y A23Y A241 A243 A245 A247 A249 A25Y A272 A276 A27X A28X A28Y A309 A30Y A311 A313 A316 A319 A31X A320 A323 A326 A330 A337 A339 A33Y A340 A341 A343 A345 A349 A34Y A35Y A362 A364 A366 A369 A377 A379 A37Y A381 A383 A385 A387 A389 A38X A394 A396 A398 A39Y A400 A402 A40Y A41Y A425 A428 A432 A435 A437 A43X A44Y A451 A453 A455 A457 A459 A45X A48Y A495 A497 A499 A501 A503 A505 A50X A519 A51Y A521 A523 A525 A527 A529 A52X A533 A53X A53Y A555 A557 A559 A55Y A562 A565 A56X A587 A589 A58Y A591 A593 A595 A59X A609 A60Y A615 A617 A61X A61Y A670 A671 A673 A674 A675 A677 A679 A67X A681 A683 A685 A686 A687 A688 A689 A68X A693 A695 A696 A697 A698 A699 A69X A70X

(19)

(72) Inventors HORST BEYER and HANS-JÜRGEN VEUTGEN

(54) WEAR-RESISTANT CAST-IRON ALLOY

(71) We, GOETZEWERKE FRIEDRICH GOETZE AKTIENGESELLSCHAFT, a Body Corporate organised and existing under the laws of the Federal Republic of Germany, of Bürgermeister-Schmidt-Strasse 17, 5763 Burscheid, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a wear-resistant cast iron alloy suitable for the construction of machine parts subject to high frictional stresses.

Machine elements subjected to friction are strongly stressed both with regard to wear and thermally, so that particularly high demands have to be made on their materials. Certain machine elements, such as the piston rings of internal combustion engines and the sealing strips of rotary piston engines, are furthermore subjected to particularly heavy stresses. Experience has shown that only very expensive materials of complicated manufacture withstand such high stresses. Usually, these materials are sintered metal carbides, to which very specific alloying elements have been added.

The sorts of cast iron so far tested, however, cannot be used for these highly stressed machine parts. It is known that the wear resistance of cast iron can be increased by the addition of alloying elements. On solidification of the cast iron, however, these elements form relatively coarse grains and very hard carbides, which then cause damage, accompanied by scoring, to the contacting surfaces. At the same time, carbide formation uses up the greater part of the carbon, so that these alloys do not contain in their structure the necessary graphite for emergency running of machine elements. Furthermore, these materials are so brittle that they are unable to withstand mechanical stresses and therefore break.

In accordance with the present invention there is provided a wear-resistant cast iron alloy, suitable for the construction of machine parts subject to high frictional stresses, the alloy containing

1.5 to 4.0% by weight of carbon
1.5 to 6.0% by weight of silicon
less than 0.2% by weight of sulphur
less than 2.5% by weight of phosphorus
1.0 to 7.0% by weight of copper
0.4 to 3.2% by weight of nickel and/or cobalt
0.1 to 1.8% by weight of tin and/or antimony
0.1 to 4.0% by weight of molybdenum
0.1 to 4.0% by weight of tungsten
0.05 to 2.5% by weight of manganese

0.3 to 2.5% by weight of chromium
0.3 to 4.0% by weight of vanadium
0 to 2.0% by weight of titanium
0.1 to 4.0% by weight of niobium and/or tantalum
0.1 to 2.0% by weight of aluminium

and the rest iron except for atmospheric nitrogen combined with the metals as a result of melting and heat treatment.

The cast iron alloys in accordance with the invention display uncombined carbon as lamellar and primarily nodular precipitates. There are also present however a large number of carbides in a very fine crystalline precipitated form.

The sum of the elements carbon and silicon in the alloys in accordance with the invention is equal to or greater than 3% by weight and the ratio of silicon to carbon is preferably equal to or greater than one. The sum of the elements molybdenum, tungsten and manganese should preferably be between 0.2 and 10% while the sum of the elements chromium, vanadium, tantalum and niobium should preferably be between 1 and 10%.

In addition, it has been found that for refining the form of the individual structural constituents, more particularly that of the graphite, and the nitrides (when present), the elements boron, bismuth, zirconium, magnesium and/or the rare-earth metals may be added. Their total concentration should not, however, exceed the value of 0.5 percent by weight.

By heat treament above 700°C, followed by quenching for example in air or a salt bath to a temperature of below 500°C, and subsequent tempering up to a temperature of 700°C, wear resistance and compatibility with the counter-material are greatly increased.

The alloys according to the invention have a bainitic to martensitic basic structure. The graphite precipitates are lamellar to nodular, the carbide precipitates are punctiform to spherical. The hardness of this material at HV 5 lies at 550 to 920 kg/mm². The material is not brittle and cast sealing strips for rotary piston engines are wear resistance and in test runs exhibit very good wear resistance with the trochoidal surface of the rotary piston engine.

The embodiment example describes one of the cast-iron alloys according to the invention. The cast-iron melt comprises the elements

2.2% by weight carbon
3.9% by weight silicon
0.9% by weight phosphorus
0.08% by weight sulphur
1.4% by weight copper
0.6% by weight nickel
0.2% by weight tin
1.5% by weight molybdenum
3.4% by weight tungsten
0.9% by weight manganese
0.4% by weight chromium
1.5% by weight vanadium
0.2% by weight titanium
0.7% by weight niobium
0.01% by weight boron
0.22% by weight aluminium

and the rest iron.

After inoculation with one of the usual inoculants, sealing strips for rotary piston engines were cast from the melt using the sand mould casting process, the dimensions of the strips being 61.03×8.3×4.95 mm. They were then annealed for one hour at 850°C, quenched in an oil bath at room temperature and tempered for one hour at 350°C.

The sealing strips thus made had an HV 5 hardness of 644 to 713 kg/mm². In test runs, the sealing strips showed very good wear resistance, while the trochoidal running surfaces were only slightly affected.

Figures 1 to 4 show photomicrographs of the cast-iron alloy of the example.

Figure 1 is the unetched specimen at a magnification of ×100, showing the graphite in lamellar to nodular form.

Figure 2 is the unetched specimen at a magnification of ×500, showing in addition to the dark graphite precipitates, the finely crystalline carbide constituents as light areas with a dark edge.

Figure 3 shows a specimen etched with HNO_3 at a magnification of ×500 which shows, in addition to the graphite precipitates and the crystalline carbide constituents, the bainitic to martensitic structure.

Figure 4 shows the phosphide eutectic, deeply etched, at a magnification of ×20.

WHAT WE CLAIM IS:—

1. A wear resistant cast iron alloy, suitable for the construction of machine parts subject to high frictional stresses, the alloy containing

1.5 to 4.0% by weight of carbon
1.5 to 6.0% by weight of silicon
less than 0.2% by weight of sulphur
less than 2.5% by weight of phosphorus
1.0 to 7.0% by weight of copper
0.4 to 3.2% by weight of nickel and/or cobalt
0.1 to 1.8% by weight of tin and/or antimony
0.1 to 4.0% by weight of molybdenum
0.1 to 4.0% by weight of tungsten
0.05 to 2.5% by weight of manganese
0.3 to 2.5% by weight of chromium
0.3 to 4.0% by weight of vanadium
0 to 2.0% by weight of titanium
0.1 to 4.0% by weight of niobium and/or tantalum
0.1 to 2.0% by weight of aluminium

and the rest iron except for atmospheric nitrogen combined with the metals as a result of melting and heat treatment.

2. An alloy as claimed in Claim 1 modified by the addition of up to 0.5% by weight in total of one or more of the elements boron, bismuth, magnesium, zirconium and rare earth metals.

3. An alloy as claimed in Claim 1 or 2 which has been subjected to heat treatment by annealing above 700°C, quenching to below 500°C and then tempering up to a temperature of 700°C.

REDDIE & GROSE,
Agents for the Applicants,
6 Bream's Buildings,
London, EC4A 1HN.

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1977
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

FIG. 1

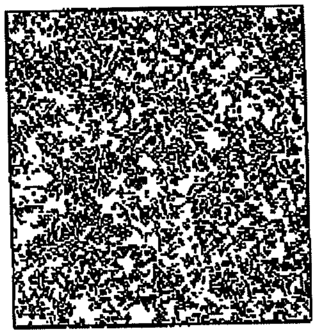

FIG. 2

FIG. 3

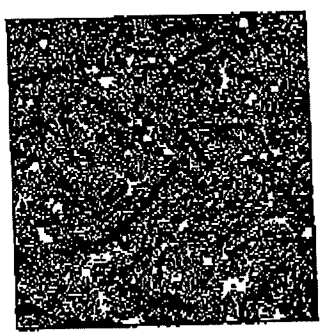

FIG. 4